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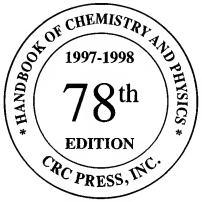

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ercentages. Titanium oxide bands are prominent in the spectra of M-type stars. The element is the ninth most abundant in the crust of the earth. ium is almost always present in igneous rocks and in the sediments derived from them. It occurs in the minerals *rutile, ilmenite,* and *sphene*, and nt in titanates and in many iron ores. Deposits of ilmenite and rutile are found in Florida, California, Tennessee, New York, and elsewhere. ium is present in the ash of coal, in plants, and in the human body. The metal was a laboratory curiosity until Kroll, in 1946, showed that titanium e produced commercially by reducing titanium tetrachloride with magnesium. This method is largely used for producing the metal today. The an be purified by decomposing the iodide. Titanium, when pure, is a lustrous, white metal. It has a low density, good strength, is easily fabricated, excellent corrosion resistance. It is ductile only when it is free of oxygen. The metal burns in air and is the only element that burns in nitrogen. m is resistant to dilute sulfuric and hydrochloric acid, most organic acids, moist chlorine gas, and chloride solutions. Natural titanium consists sotopes with atomic masses from 46 to 50. All are stable. Fifteen other unstable isotopes are known. The metal is dimorphic. The hexagonal changes to the cubic β form very slowly at about 880°C. The metal combines with oxygen at red heat, and with chlorine at 550°C. Titanium rtant as an alloying agent with aluminum, molybdenum, manganese, iron, and other metals. Alloys of titanium are principally used for aircraft sides where lightweight strength and ability to withstand extremes of temperature are important. Titanium is as strong as steel, but 45% lighter. s heavier than aluminum, but twice as strong. Titanium has potential use in desalination plants for converting sea water into fresh water. The has excellent resistance to sea water and is used for propeller shafts, rigging, and other parts of ships exposed to salt water. A titanium anode with platinum has been used to provide cathodic protection from corrosion by salt water. Titanium metal is considered to be physiologically owever, titanium powder may be a carcinogenic hazard. When pure, titanium dioxide is relatively clear and has an extremely high index of ion with an optical dispersion higher than diamond. It is produced artificially for use as a gemstone, but it is relatively soft. Star sapphires and exhibit their asterism as a result of the presence of TiO_2. Titanium dioxide is extensively used for both house paint and artist's paint, as it is ent and has good covering power. Titanium oxide pigment accounts for the largest use of the element. Titanium paint is an excellent reflector ared, and is extensively used in solar observatories where heat causes poor seeing conditions. Titanium tetrachloride is used to produce glass. This und fumes strongly in air and has been used to produce smoke screens. The price of titanium metal (99.8%) is about $550/kg.

ngsten — (Swedish, *tung sten*, heavy stone); also known as *wolfram* (from *wolframite*, said to be named from *wolf rahm* or *spumi lupi*, because interfered with the smelting of tin and was supposed to devour the tin), W; at. wt. 183.84(1); at. no. 74; m.p. 3422 ± 20°C; b.p. 5555°C; sp. s (20°C); valence 2, 3, 4, 5, or 6. In 1779 Peter Woulfe examined the mineral now known as *wolframite* and concluded it must contain a new nce. Scheele, in 1781, found that a new acid could be made from *tung sten* (a name first applied about 1758 to a mineral now known as *scheelite*). le and Bergman suggested the possibility of obtaining a new metal by reducing this acid. The de Elhuyar brothers found an acid in *wolframite* ed that was identical to the acid of *tungsten*(tungstic acid) of Scheele, and in that year they succeeded in obtaining the element by reduction of cid with charcoal. Tungsten occurs in *wolframite*, (Fe, Mn)WO_4; *scheelite*, $CaWO_4$; *huebnerite*, $MnWO_4$; and *ferberite*, $FeWO_4$. Important cks of tungsten occur in California, Colorado, South Korea, Bolivia, Russia, and Portugal. China is reported to have about 75% of the world's en resources. Natural tungsten contains five stable isotopes. Thirty two other unstable isotopes and isomers are recognized. The metal is obtained ercially by reducing tungsten oxide with hydrogen or carbon. Pure tungsten is a steel-gray to tin-white metal. Very pure tungsten can be cut with saw, and can be forged, spun, drawn, and extruded. The impure metal is brittle and can be worked only with difficulty. Tungsten has the highest g point of all metals, and at temperatures over 1650°C has the highest tensile strength. The metal oxidizes in air and must be protected at elevated eratures. It has excellent corrosion resistance and is attacked only slightly by most mineral acids. The thermal expansion is about the same as cificate glass, which makes the metal useful for glass-to-metal seals. Tungsten and its alloys are used extensively for filaments for electric lamps, n and television tubes, and for metal evaporation work; for electrical contact points for automobile distributors; X-ray targets; windings and g elements for electrical furnaces; and for numerous spacecraft and high-temperature applications. High-speed tool steels, Hastelloy®, Stellite®, ny other alloys contain tungsten. Tungsten carbide is of great importance to the metal-working, mining, and petroleum industries.Calcium and esium tungstates are widely used in fluorescent lighting; other salts of tungsten are used in the chemical and tanning industries. Tungsten disulfide y, high-temperature lubricant, stable to 500°C. Tungsten bronzes and other tungsten compounds are used in paints. Tungsten powder (99.95%) bout $325/kg.

anium — (Planet *Uranus*), U; at. wt. 238.0289(1); at. no. 92; m.p. 1135°C; b.p. 4131°C; sp. gr. ~18.95; valence 2, 3, 4, 5, or 6. Yellow-colored waxinite more than 1% uranium oxide and dating back to 79 A.D., has been found near Naples, Italy. Klaproth recognized an unknown element *blende* and attempted to isolate the metal in 1789. The metal apparently was first isolated in 1841 by Peligot, who reduced the anhydrous chloride tassium. Uranium is not as rare as it was once thought. It is now considered to be more plentiful than mercury, antimony, silver, or cadmium, about as abundant as molybdenum or arsenic. It occurs in numerous minerals such as *pitchblende, uraninite, carnotite, autunite, uranophane,* e, and *tobernite*. It is also found in *phosphate rock, lignite, monazite sands*, and can be recovered commercially from these sources. Large sits of uranium ore occur in Utah, Colorado, New Mexico, Canada, and elsewhere. The U.S.D.O.E. purchases uranium in the form of acceptable concentrates. This incentive program has greatly increased the known uranium reserves. Uranium can be made by reducing uranium halides with or alkaline earth metals or by reducing uranium oxides by calcium, aluminum, or carbon at high temperatures. The metal can also be produced drolysis of KUF_5 or UF_4, dissolved in a molten mixture of $CaCl_2$ and NaCl. High-purity uranium can be prepared by the thermal decomposition anium halides on a hot filament. Uranium exhibits three crystallographic modifications as follows:

$$\alpha \xrightarrow{668°C} \beta \xrightarrow{776°C} \gamma$$

ium is a heavy, silvery-white metal which is pyrophoric when finely divided. It is a little softer than steel, and is attacked by cold water in a finely ed state. It is malleable, ductile, and slightly paramagnetic. In air, the metal becomes coated with a layer of oxide. Acids dissolve the metal, but affected by alkalis. Uranium has twenty three isotopes, one of which is an isomer and all of which are radioactive. Naturally occurring uranium ists 99.2745% by weight ^{238}U, 0.720% ^{235}U, and 0.0055% ^{234}U. Studies show that the percentage weight of ^{235}U in natural uranium varies by ut as 0.1%, depending on the source. The U.S.D.O.E. has adopted the value of 0.711 as being their "official" percentage of ^{235}U in natural uranium. ral uranium is sufficiently radioactive to expose a photographic plate in an hour or so. Much of the internal heat of the earth is thought to be ributable to the presence of uranium and thorium. ^{238}U with a half-life of 4.46×10^9 years, has been used to estimate the age of igneous rocks. The t of uranium, the highest member of the naturally occurring elements — except perhaps for traces of neptunium or plutonium — is not clearly